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Costs and cost-effectiveness analysis of treatment in children with eczema by nurse practitioner vs. dermatologist: results of a randomized, controlled trial and a review of international costs

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Conflicts of interest
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Summary

Background In a randomized, controlled trial (RCT) on childhood eczema we reported that substituting nurse practitioners (NPs) for dermatologists resulted in similar outcomes of eczema severity and in the quality of life, and higher patient satisfaction.

Objectives To determine costs and cost-effectiveness of care provided by NPs vs. dermatologists and to compare our results with those in studies from other countries.

Methods We estimated the healthcare costs, family costs and the costs in other sectors alongside the RCT. All the costs were linked to quality of life [Infants' Dermatitis Quality of Life Index (IDQOL), Children's Dermatology Life Quality Index (CDLQI)] and to patient satisfaction (Client Satisfaction Questionnaire-8) to determine the incremental cost-effectiveness ratio (ICER). We also examined all the reported studies on the costs of childhood eczema.

Results The mean annual healthcare costs, family costs and costs in other sectors were €658, €302 and €21, respectively, in the NP group and €801, €608 and €0·93, respectively, in the dermatologist group. The ICER in the NP group compared with the dermatologist group indicated €925 and €751 savings per one point less improvement in IDQOL and CDLQI, respectively, and €251 savings per one point more satisfaction in the NP group at 12 months. The mean annual healthcare costs and family costs varied considerably in the six identified studies.

Conclusions Substituting NPs for dermatologists is both cost-saving and cost-effective. The treatment of choice is that provided by the NPs as it is similarly effective to treatment provided by a dermatologist with a higher parent satisfaction. International comparisons are difficult because the types of costs determined, the units and unit prices, and eczema severity all differ between studies.

Educational interventions and coaching focusing on both somatic and psychological aspects have been used as an adjunct to conventional care for children with eczema to enhance the effectiveness of therapy.[1–3] The effectiveness of providing nursing intervention as an addition to conventional care by a dermatologist in children with eczema was evaluated in several studies.[4–6] Our approach is different because in our recently published randomized, controlled trial (RCT) the education and coaching by the nurse practitioner (NP) was not supplementary, but was a part of the overall treatment (i.e. also medical treatment) by the NP.[7] The effectiveness of substituting NPs for dermatologists to provide care for children with eczema was comparable in terms of severity and quality-of-life outcomes. In addition, parents whose children were treated by the NP were significantly more satisfied.

Treatment of eczema in children is accompanied by significant costs, which are covered by health insurance, the families and society. There is a need for economic evaluations of nurse-led care in the treatment of eczema in children; unfortunately the lack of rigorously designed trials provides only poor quality efforts in this area.[8] Substituting NPs for dermatologists may decrease healthcare costs. However, although using NPs may save salary costs, they may order more laboratory tests, issue more prescriptions and conduct more visits thus reducing the overall cost savings. We undertook an economic evaluation comparing NP-provided care of eczema in

children with that provided by dermatologists, alongside an RCT in which costs were measured from a societal perspective, and we present the results of a cost-effectiveness analysis. In addition, we examined the currently reported international costs of eczema in children for an accurate comparison with those in the present study.

Methods

Study population

In a randomized, parallel-group study, 160 new referrals aged ≤ 16 years with a diagnosis of eczema ('atopic dermatitis')[9] were randomized to either conventional care by a dermatologist or to care by a NP. The duration of the study was 1 year. The design, the inclusion criteria and the sample size of the RCT have been published previously.[7]

Clinical effectiveness parameters

The primary endpoints were between-group (dermatologist and NP) differences in the quality of life of the child between baseline and the follow-up at 12 months assessed by the Infants' Dermatitis Quality of Life Index (IDQOL)[10] completed by parents for children aged < 4 years, and by the illustrated version of the Children's Dermatology Life Quality Index (CDLQI)[11] completed by the children aged 4–16 years. The IDQOL and CDLQI instruments each have 10 items which are added up to provide a score that ranges from 0 to 30, with the higher scores representing a poor quality of life.

Patient satisfaction was measured by the Client Satisfaction Questionnaire-8 (CSQ-8)[12] at 12 months. Responses to the eight items on the CSQ-8 were scored on a scale from 1 (unfavourable expression) to 4 (most positive expression). The aggregated sum score has a maximum of 32, with a higher score representing more satisfaction. The CSQ-8 was completed by the parents at home and returned to the independent data entry office.

Costs

Resource data were collected prospectively during study visits with an independent investigator at 4, 8 and 12 months. A detailed registration system was set up and incorporated into the clinical record form. Visits to dermatologists and NPs, phone consultations, group education sessions, admission days and laboratory tests were registered every study visit by the investigator by comparing the medical record and the electronic hospital information system, and was completed together with the patient. Absence from work for visits to the dermatologist or NP, travelling expenses, out-of-pocket expenses, professional help at home and visits to the general practitioner were registered in a cost diary. The parents completed the diary at home and handed it over to the investigator during the next study visit. Volumes of medication used and refilled prescriptions were measured using registration forms and compared with the medical record during every study visit. This was compared with prescription records obtained from the pharmacy database. Measurement of costs covered eczema-specific costs and resource utilization. Eczema-related costs, for example costs for visits to the allergologist or dietician, are not included in the calculation. The three categories of costs were the healthcare costs (hospital costs and community costs), the family costs and the costs in other sectors, aggregated to estimate the mean annual societal costs.[13] Hospital costs were recorded from the start of the study until the last outpatient visit to the dermatologist or the NP. Community costs were recorded after treatment in hospital was completed until the end of the 1-year study period.

Unit prices and cost calculations

Estimates of unit costs were based on the Dutch guideline prices.[14] Group education sessions of 2 h were calculated and divided by the number of participants to determine the allocated amount per patient. Costs of laboratory tests were based on charges.[14] Costs of medications were based on the listed prices, including value added tax, obtained from the website of the Dutch Health Insurance Board (http://www.fk.cvz.nl). Travel costs by private car or public transport were based on the distance travelled to the hospital. Travelling expenses were calculated per visit. The mean distance to hospital was 11·7 km (23·4 km per visit), and cost per km amounted to €0·17. In addition, parking costs were estimated at €2·64 per visit when a private car was used for transportation. Costs due to productivity losses were based on an overall mean hour productivity cost for men and women, calculated according to the human capital approach.[14] Costs of productivity losses by the parents only include losses due to visits to healthcare providers.

Multiplying the respective volumes of resource use with their corresponding unit prices resulted in the associated total costs. Costs were calculated in the European currency (Euro). The price level is that of 2008. A detailed outline of the cost categories, determinations, units and unit prices that were assessed is presented in Table 1.

Statistical analysis

For the objective SCORAD (SCORing AD), quality-of-life outcomes and patient satisfaction, the paired t-test was used for *post-hoc* comparisons within the treatment groups and the unpaired t-test for comparisons between the treatment groups. In case scores were not normally distributed, the Friedman test was used for comparisons within groups, and the Mann–Whitney U-test for between-group comparisons.

Descriptive analyses were used to describe the mean costs per patient in both treatment groups. Differences in costs between the intervention group and the control group after 12 months of the study were presented based on the trial data, and 95% confidence intervals (CIs) were computed based on bootstrap resampling with 5000 replications of the trial

Table 1 Types of costs, determinations, unit and unit prices

Types of costs	Determination	Unit	Unit price (€)
Healthcare costs hospital			
Visits dermatologist[a]	Number of visits, salary costs calculated to invested time	Min	1·66
Visits NP[b]	Number of visits, salary costs calculated to invested time	Min	0·52
Phone consultations dermatologist[c]	Number of visits, salary costs calculated to invested time	Min	8·30
Phone consultations NP[d]	Number of visits, salary costs calculated to invested time	Min	5·20
Prescriptions	Quantities of medication and unit prices	Prescription	Diverse
Laboratory tests	Number of tests		Diverse
Admission day	The number of bed days, standard price	Day	512
Group education session by the NP	Specific salary costs calculated to invested time divided by the number of participants		Diverse
Healthcare costs community			
Visits GP	Number of visits, standard price	Visit	21·70
Prescriptions	Quantities of medication and unit prices		Variable
Family costs			
Absence from work	Time investment, mean income Dutch population costs	Hour	37·23
Travelling expenses	Standard price for private car/public transport based on mean distance to hospital	Visit	6·72/4·04
Out-of-pocket	Resources used		Variable
Costs in other sectors			
Home help visits	Number of visits, invested time	Hour	32·97

NP, nurse practitioner; GP, general practitioner. [a]First visit 20 min, follow-up visits 10 min; [b]first visit NP 30 min, follow-up visits 20 min; [c]phone consultations 5 min; [d]phone consultations NP 10 min.

data. Separate estimates were made for different cost categories. The costs of care by the dermatologist and the NP were estimated for different eczema severity rates.

For the cost-effectiveness analyses, mean annual societal costs were linked to quality of life (IDQOL and CDLQI) and to patient satisfaction (CSQ-8). Point estimates for the incremental cost-effectiveness ratio (ICER) were computed on complete cost-effect pairs by dividing the incremental societal costs by the incremental effects at 12 months. We estimated uncertainty around the ICERs using bootstrapping, generating 5000 replications of the original dataset. The percentage of patients who fell into each of the four quadrants of the cost-effectiveness plane was determined. A cost-effectiveness acceptability curve (CEAC) was generated representing the probability that care by the NP was more effective compared with care by the dermatologist over a range of thresholds.[13,15]

Finally, a sensitivity analysis was performed to examine the robustness of our findings. We investigated the scenario when 60% of the children in the NP group participated in a 1-h group education session with five children per group. We have assumed an average decrease of 0·5 visits per child in the NP group. This scenario was based on expert opinions of the professionals at our department.

Literature review

A literature search was conducted in October 2009 for an overview of the cost-of-illness (COI) of eczema in children worldwide. Medline, EMBASE, the Cochrane library database and the CINAHL databases were searched. There was no restriction on language or country of origin. Search terms were atopic dermatitis, atopic eczema, eczema, costs, cost analysis, economics, child, infant and adolescent. Studies in which the cost of eczema in children and adults was combined were excluded if we were unable to extract data that related to children. MeSH terms and text word combinations were used. We also hand searched the reference lists of all identified studies for additional studies.

The selected papers were independently appraised in terms of their methodological quality by using the Consensus on Health Economic Criteria (CHEC)-list[16] and data were extracted by three reviewers (M.L.A.S., K.M.V., P.J.C.). Differences of opinion were resolved by consensus. Because there is no generally accepted list of criteria for reviewing economic evaluations based on COI studies, we used the CHEC-list, which was developed for reviews of full economic evaluations based on effectiveness studies. The CHEC-list consists of 19 yes-or-no questions. In the evaluation of the COI studies some items on effectiveness could not be assessed and were scored as not applicable. As a generic measure adjusted for 'not applicable' we determined the percentage of 'yes' answers from the total answered questions. The data extraction took place by means of a data extraction form that was set up by the authors.

COI estimates for each country were converted into Euro (€) using an exchange rates website (http://www.x-rates.com). We choose 31 December as the standard for the year of the original study. The cost estimates for each country were adjusted for inflation beginning with the year of data sampling of the original paper and then indexed to the price level

of 2008 using the consumer price index on the website of Centraal Bureau voor de Statistiek (CBS), the Netherlands (http://cbs.nl).

Results

In this RCT, 79 patients were allocated to the dermatologist group and 81 to the NP group. The severity of the eczema measured by the mean objective SCORAD[17] (SD) did not differ significantly between the treatment groups at baseline [in children aged < 4 years: dermatologist group 33·4 (19·3), NP group 33·4 (15·6); and in children aged 4–16 years: dermatologist 35·4 (17·3), NP 29·9 (16·0)]. The difference of only 5·5 points between the dermatologist and NP groups in the age group 4–16 years cannot be assumed to be clinically relevant as the range of the objective SCORAD is from 0 to 83. More details on the baseline characteristics have been reported elsewhere.[7]

Clinical effectiveness

In children aged < 4 years, the mean number of outpatient visits per patient was 4·5 in the dermatologist group and 3·5 in the NP group ($P = 0·043$). In children aged 4–16 years, there was no significant difference between the dermatologists (3·6) and the NPs (3·7). The mean number of telephone consultations per patient was significantly higher in the NP group both in children aged < 4 years ($P < 0·001$) and in children aged 4–16 years ($P = 0·003$). The mean time investment (outpatient visits, phone consultations) per patient per year was 52 min in the dermatologist group and 100 min in the NP group. In the NP group, on average, five parents in each age group participated in one group education session of 2 h. The mean hospital period was 9·3 months in the dermatologist group and 7·4 months in the NP group.

The mean IDQOL score in the dermatologist group improved significantly from 11·6 (SD 8·1; 95% CI 9·0–14·2) at baseline to 5·6 (SD 3·9; 95% CI 4·3–7·0) at 12 months with a mean change from baseline of −6·5 (SD 6·6; 95% CI −14·2 to −8·9; $P < 0·001$). The mean IDQOL score in the NP group improved significantly from 10·7 (SD 4·9; 95% CI 9·1–12·3) at baseline to 5·7 (SD 5·4; 95% CI 4·0–7·5) at 12 months with a mean change from baseline of −4·9 (SD 5·5; 95% CI −6·8 to −3·0; $P < 0·001$). The between-groups difference was (−)1·7 (95% CI −4·6 to 1·2; $P = 0·26$).

The mean CDLQI score in the dermatologist group improved significantly from 12·1 (SD 6·3; 95% CI 9·9–14·2) at baseline to 5·6 (SD 4·2; 95% CI 4·2–7·1) at 12 months with a mean change from baseline of −5·9 (SD 6·0; 95% CI −8·0 to −3·9; $P < 0·001$). The mean CDLQI score in the NP group improved significantly from 10·0 (SD 4·4; 95% CI 8·5–11·4) at baseline to 4·9 (SD 3·5; 95% CI 3·7–6·1) at 12 months with a mean change from baseline of −5·2 (SD 4·0; 95% CI −6·6 to −3·8; $P < 0·001$). The between-groups difference was (−)0·7 (95% CI −3·3 to 1·7; $P = 0·55$).

The CSQ-8 scores were 24·8 (SD 4·3; 95% CI 23·6–26·0) in the dermatologist group and 26·9 (SD 4·9; 95% CI 25·5–28·2) in the NP group at the 12-month follow-up. The between-groups comparisons showed a significant difference at 12 months of (−)2·1 (95% CI −3·0 to −0·3; $P < 0·02$) in favour of the NP group.

Costs

In the present study, data were analysed for children for whom cost data were available: 76 in the dermatologist group and 71 in the NP group. The mean resource use for the dermatologist and NP groups is described in Table 2. The mean annual societal costs per patient were €1409 in the dermatologist group and €981 in the NP group (mean difference −€428; 95% CI −910 to 197). In the dermatologist group these costs were €1791 in children aged < 4 years and €1039 in children aged 4–16 years. In the NP group these costs were €1186 in children aged < 4 years and €778 in children aged 4–16 years.

The mean costs for each resource item are described in Table 3. The costs of dermatologist care and NP care estimated for different eczema severity levels are shown in Table 4.

Healthcare costs

Mean annual healthcare costs were higher in the dermatologist group (€801) than in the NP group (€658) (mean difference −€143; 95% CI −544 to 299). In the hospital period, these costs were €771 in the dermatologist group and €632 in the NP group. In the dermatologist group, higher costs were noted for outpatient visits, laboratory tests and medication. Costs for phone consultations and protective dressings were

Table 2 Mean (SD) total costs (€) and cost difference per child during the 1-year study period: nurse practitioner vs. dermatologist

	Nurse practitioner (n = 76)	Dermatologist (n = 71)	Difference[a] (95% CI)
Healthcare costs hospital	632 (1198)	771 (1590)	−139 (−520 to 291)
Healthcare costs community	26 (39)	30 (59)	−4 (−17 to 12)
Family costs	302 (511)	608 (1018)	−306 (−475 to −16)
Costs other sectors	21 (182)	0·93 (7·83)	20 (−3 to 59)
Total costs	981 (1339)	1409 (2289)	−428 (−910 to 197)

CI, confidence interval. [a]Negative cost differences represent lower costs in the nurse practitioner arm.

Table 3 Mean (SD) costs (€) and cost difference per child per resource item during the 1-year study period: nurse practitioner (NP) vs. dermatologist

	Nurse practitioner (n = 76)	Dermatologist (n = 71)	Difference[a] (95% CI)
Healthcare costs hospital			
Outpatient visits	272 (143)	422 (238)	−150 (−194 to −75)
Phone consultations	7·22 (9·23)	3·63 (7·72)	3·59 (0·91 to 5·93)
Oral medication	14 (36)	19 (30)	−5 (−14 to 6)
Ointments active ingredients	69 (80)	87 (113)	−18 (−42 to 15)
Emollients	17 (19)	17 (22)	0 (−6·48 to 5·92)
Bandages, dressings	47 (69)	26 (60)	21 (2 to 40)
Laboratory tests	9 (33)	17 (40)	−8 (−17 to 4)
Hospital admission days	179 (1133)	163 (1376)	16 (−334 to 380)
Group education, NP	4·63 (7·91)	–	4·63 (2·65 to 5·89)
Healthcare cost community			
General practitioner	10 (28)	18 (36)	−8 (−15 to 3)
Oral medication[b]	3·06 (13·42)	2·81 (10·30)	0·25 (−2·97 to 4·05)
Ointments with active ingredients[c]	6·54 (21·09)	7·14 (40·20)	−0·86 (−10·43 to 7·62)
Emollients	3·20 (5·79)	1·45 (3·93)	1·75 (0·28 to 3·08)
Protective dressings[d]	2·64 (11·07)	0 (0)	2·64 (0·48 to 4·88)
Total healthcare costs	658 (1213)	801 (1607)	−143 (−544 to 299)
Family costs			
Time costs[e]	178 (357)	415 (735)	−237 (−360 to −37)
Travelling expenses	20 (18)	30 (26)	−10 (−13 to −1)
Bath oil	21 (20)	23 (26)	−2 (−8 to 6)
Out-of-pocket[f]	83 (370)	134 (684)	−51 (−221 to 97)
Costs other sectors			
Home-help visits	21 (182)	0·93 (7·83)	20 (−3 to 59)

[a]Negative cost differences represent lower costs in the NP arm; [b]antibiotics, antihistamines; [c]steroids, calcineurin inhibitors, tar; [d]bandages, garments and gloves; [e]time missed in paid work and days missed in nonworking activities of the parents; [f]self-medication, alternative practitioner, carpet changes, nutrition.

slightly higher in the NP group. In the community period, the costs for visits to the general practitioner were €18 in the dermatologist group and €10 in the NP group.

Family costs

Mean annual family costs were twice as high in the dermatologist group (€608) than in the NP group (€302) (mean difference −€306; 95% CI −475 to −16). Time costs because of visits to healthcare providers were €415 in the dermatologist group and €178 in the NP group. Costs for out-of-pocket expenses were €134 in the dermatologist group and €83 in the NP group.

Costs in other sectors

Mean annual costs for home help visits, which are paid by the state in the Netherlands, were €21 in the NP group and €0·93 in the dermatologist group.

Cost-effectiveness analyses

The results of the cost-effectiveness analyses are shown in Figure 1. The point estimate for the ICER was €925 indicating that one point less improvement in IDQOL in the NP group compared with the dermatologist group at 12 months would save €925. However, the effectiveness of the two interventions was comparable with a clear difference in costs in favour of the NP group. Therefore an ICER provides little additional information. For that reason we performed bootstrapping, which showed a 95% CI of −€5748 to €6667. The cost-effectiveness plane showed that 51% of the cost-effect pairs were plotted in the southwest quadrant, indicating lower costs and less effect in the NP group. Twenty-nine per cent of the resamples were located in the southeast quadrant indicating lower costs and more effect in the NP group. The CEAC showed that without additional investment the probability that the NP is cost-effective is 80%, which decreases quickly by investment because the benefit can only be explained by lower costs and not by gained quality of life.

For the CDLQI, the ICER was €751 per one point less improvement in CDLQI in the NP group. Bootstrapping showed a CI of −€3653 to €3213. The cost-effectiveness plane showed that 59% of the cost-effect pairs were plotted in the southwest quadrant, indicating lower costs and less effect in the NP group. Thirty-seven per cent of the cost-effect pairs were located in the southeast quadrant, which indicates lower costs as well as more effect in the NP group. The CEAC

Table 4 Mean (SD) costs (€) per child with respect to severity levels during the 1-year study period: nurse practitioner (NP) vs. dermatologist

	Nurse practitioner			Dermatologist		
	Mild eczema (n = 12)	Moderate eczema (n = 44)	Severe eczema (n = 20)	Mild eczema (n = 13)	Moderate eczema (n = 31)	Severe eczema (n = 29)
Healthcare costs hospital						
Outpatient visits	178 (85)	270 (147)	340 (143)	257 (152)	404 (206)	521 (260)
Phone consultations	1·21 (1·99)	6·55 (8·13)	13 (12)	3·93 (9·49)	2·04 (6·33)	5·17 (8·05)
Oral medication	0 (0)	15 (44)	20 (26)	16 (33)	12 (21)	28 (35)
Ointments active ingredients	35 (50)	71 (88)	85 (72)	26 (24)	83 (122)	118 (118)
Emollients	18 (18)	18 (21)	13 (17)	18 (12)	16 (17)	19 (30)
Bandages, dressings	15 (29)	45 (73)	73 (70)	16 (57)	17 (49)	40 (71)
Laboratory tests	11 (34)	12 (39)	0·45 (2·0)	7·62 (20·74)	19 (33)	19 (53)
Hospital admission days	0 (0)	0 (0)	6·80 (2·71)	0 (0)	0 (0)	429 (2239)
Group education, NP	4·4 (9·52)	5·84 (8·48)	2·10 (4·61)	–	–	–
Total	287 (141)	450 (280)	1237 (2222)	386 (149)	567 (284)	1192 (2528)
Healthcare costs community						
General practitioner	11 (25)	13 (33)	3·3 (10·6)	13 (24)	11 (22)	25 (47)
Oral medication[a]	0 (0)	4·9 (17)	0·9 (3·9)	8·90 (17·40)	1·69 (8·93)	1·27 (6·00)
Ointments with active ingredients[b]	1·23 (3·4)	3·16 (10·6)	17 (36)	8·30 (21·80)	2·20 (6·68)	12 (62)
Emollients	3·97 (6·5)	3·50 (6·3)	2·1 (3·89)	2·75 (6·25)	1·17 (2·76)	1·18 (3·72)
Protective dressings[c]	3·24 (8·60)	1·15 (7·74)	5·47 (16·90)	0 (0)	0 (0)	0 (0)
Total	19 (27)	26 (40)	30 (43)	35 (57)	17 (25)	42 (82)
Total healthcare costs	307 (146)	476 (275)	1267 (2254)	420 (144)	584 (295)	1234 (2553)
Family costs						
Time costs[d]	31 (72)	153 (291)	320 (520)	315 (428)	256 (396)	645 (1048)
Travelling expenses	13 (16)	20 (17)	26 (20)	17 (13)	25 (20)	42 (32)
Bath oil	17 (63)	301 (560)	440 (516)	25 (50)	22 (17)	23 (22)
Out-of-pocket[e]	15 (28)	110 (432)	64 (113)	33 (37)	233 (1023)	69 (201)
Total	77 (63)	301 (560)	440 (516)	366 (440)	522 (1068)	761 (1141)
Costs other sectors						
Home-help visits	0 (0)	36 (239)	0 (0)	0 (0)	0 (0)	2·13
Total costs all categories	384 (128)	814 (707)	1707 (2256)	811 (518)	1128 (1100)	2022 (3452)

[a]Antibiotics, antihistamines; [b]steroids, calcineurin inhibitors, tar; [c]bandages, garments and gloves; [d]time missed in paid work and days missed in nonworking activities of the parents; [e]self-medication, alternative practitioner, carpet changes, nutrition.

showed that without additional investment the probability that the NP is cost-effective is 96%, but this decreases quickly by investment because the benefit can only be explained by lower costs in the NP group and not by gained quality of life.

For the CSQ-8, ICER was €251, which means per patient €251 lower costs per one point more satisfaction in the NP group. Bootstrapping showed a CI of −€1555 to €146. Ninety-two per cent of the replicates were plotted in the southeast quadrant, which means that treatment by the NP gave lower costs and more satisfaction. The CEAC showed that without additional investment the probability that the NP is cost-effective is 94% which increases to 99% by some investment.

In the sensitivity analysis, the mean annual societal costs per patient were €944 in the NP group instead of €981. For the CSQ-8, the ICER was €270 instead of €251 in the NP group.

Literature review

From the searches, 137 studies were identified and their abstracts were assessed. Criteria for study selection included availability of estimates of healthcare and/or family costs of eczema in infants or children or adolescents. Both COI studies and cost-effectiveness studies were taken into account, as the aim was to give an overview of the COI of eczema in children without restricting the selection to any particular objectives. We excluded studies in which the cost of eczema in children and adults was combined because we were unable to extract data that related to children. Six studies were included in this review. The studies reported the costs of eczema in children in Australia,[18] Germany,[19–21] U.K.[22] and Italy.[23] Five articles concerned COI studies,[18,20–23] and one study concerned cost-effectiveness.[19] An overview of the characteristics of the studies is shown in Table 5.

The results of methodological assessment are shown in Table 6. Three out of five COI studies[18,20,22] scored ≥ 50% positive answers. The COI study of Emerson *et al.*[22] scored the best with a percentage of 77% (10 out of 13).

The studies used different frameworks to evaluate costs. An overview is shown in Table 7. Witt *et al.*[19] compared the cost-effectiveness of homoeopathic vs. conventional therapy for eczema in children. To compare our study with the five COI

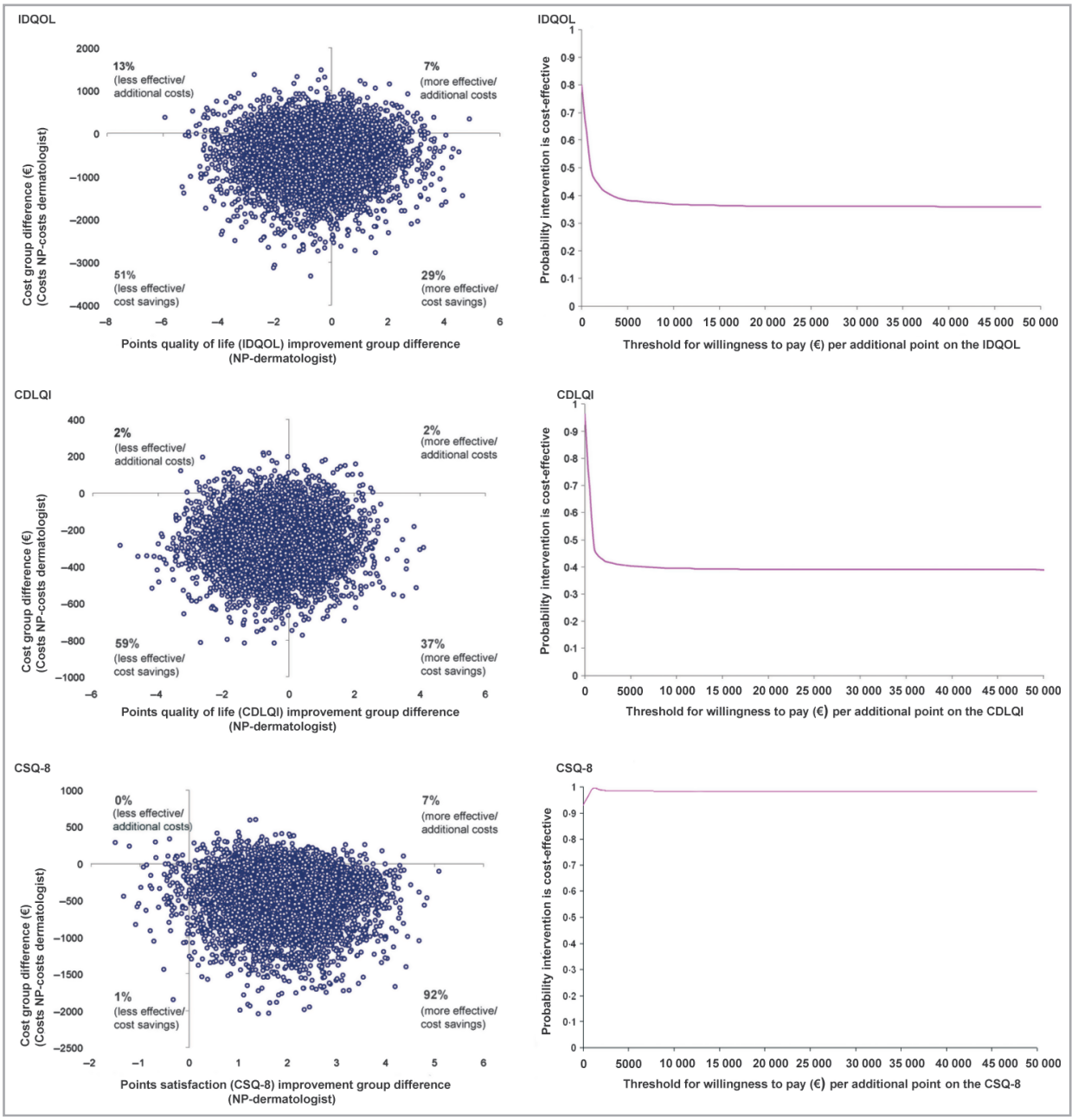

Fig 1. Bootstrapped costs and effects per outcome parameter (left panels) and cost-effectiveness acceptability curves displaying the probability of the nurse practitioner (NP) being cost-effective compared with the care as usual (right panels). Substantial proportions of the joint density (ΔC, ΔE) cover all four quadrants of the cost-effectiveness plane. For Infants' Dermatitis Quality of Life Index (IDQOL) and Children's Dermatology Life Quality Index (CDLQI), the majority is contained within the southwest quadrant (less costly, less effective). For the Client Satisfaction Questionnaire-8 (CSQ-8), the majority is contained within the southeast quadrant (more effective, less costly).

studies we have only included the costs of conventional therapy in our comparison.

Comparison of healthcare costs

In the U.K., in 2001, Emerson *et al.*[22] reported annual costs of €90 in children with eczema. The severity of eczema was largely mild (83%), the visits were mainly in primary care, and there were no costs for hospital admission, which explains the lower costs compared with the other studies.

In Germany, in 2000, Rathjen *et al.*[21] reported annual costs of €1498 in moderate to severe eczema. Hospitalization, €384, and rehabilitation clinic, €526, were included. In 2003, Weinmann *et al.*[20] reported eczema-specific costs in a birth cohort in which children with atopic diseases were included. Costs were expressed as costs per disease-year and

Table 5 Characteristics of the studies reviewed on costs of eczema treatment in children

	Study					
	Su *et al.*, Australia 1997[18]	Rathjen *et al.*, Germany 2000[21]	Emerson *et al.*, U.K. 2001[22]	Weinmann *et al.*, Germany 2003[20]	Ricci *et al.*, Italy 2006[23]	Witt *et al.*, Germany 2009[19]
Number, age (years)	48, 0·3–15	204, NR	290, 1–5	91, 0–8	33, 1–9	87, 1–14
Recruitment	Hospital, referrals to the dermatology clinic	NR	Postal questionnaire in four general practices	Birth cohort (MAS)[24]	Hospital, referrals to allergy/immunology/ paediatric department	Referrals to paediatrician or dermatologist
Diagnosis eczema	Physician diagnosis	Physician diagnosis	Physician diagnosis based on U.K. refinement diagnostic criteria for AD[25]	Physician diagnosis and questionnaire	Hanifin and Rajka[26]	U.K. working party[27,28]
Eczema severity	Rajka and Langeland criteria[29]	SCORAD index[30]	Global clinical assessment of severity	SCORAD index[30]	SCORAD index[31]	SCORAD index[31]
Period data collection	March–August 1995	NR	1995–6	1990–8	March–May 2003	January 2005–January 2007
Duration data collection	12 months	6 months extrapolated to 12 months	12 months	8 years recalculated to 12 months	12 months	12 months
Method of data collection	Questionnaire	Questionnaire	Questionnaire	Directly by retrospective chart reviews	Questionnaire	Questionnaire and diary
Currency	Australian dollar	Deutsche mark	British pound	Deutsche mark converted to U.S. dollar	U.S. dollar (Euro)	Euro

NR, not reported; MAS, Multicenter Atopy Study; AD, atopic dermatitis; SCORAD, scoring AD.

Table 6 Methodological quality assessment

Study	Cost analysis	Cost perspective	n	Quality assessment (CHEC) score			
				Yes	No	NA	Yes (% of total)[a]
Su *et al.* 1997[18]	Cost-of-illness	Healthcare/family	48	7	6	6	54
Rathjen *et al.* 2000[21]	Cost-of-illness	Healthcare/family	204	5	8	6	38
Emerson *et al.* 2001[22]	Cost-of-illness	Healthcare/family	290	10	3	6	77
Weinmann *et al.* 2003[20]	Cost-of-illness	Healthcare	91	7	7	5	50
Ricci *et al.* 2006[23]	Cost-of-illness	Family	33	5	9	6	38
Witt *et al.* 2009[19]	Cost-effectiveness	Healthcare/family	87	14	5	0	74

CHEC, Consensus on Health Economic Criteria; NA, not applicable. [a]Generic measure adjusted for NA.

represent the total annual eczema-specific healthcare costs of €228 in years with symptoms. Hospitalization, €30, and rehabilitation clinic, €70, were included. In 2009, Witt *et al.*[19] reported annual costs of €331 in children with mild eczema. No costs for hospitalization and rehabilitation clinic were included.

In Australia, in 1997, Su *et al.*[18] estimated annual costs of €501, €1448 and €2206 for mild, moderate and severe eczema, respectively, at a dermatology clinic. Hospital-based recruiting and costs for eczema-related visits to different physicians explain the higher costs. A large part of the healthcare costs consisted of hospitalization: in mild, moderate and severe eczema, respectively, €343, €1154 and €486. Medication was not included in this estimation.

Comparison of family costs

In the U.K., Emerson *et al.*[22] estimated annual costs of €52. In Germany, Rathjen *et al.*[21] estimated annual costs of €4068; most of these costs were because of the time spent on the treatment and the care. Witt *et al.*[19] estimated annual costs of €360. In Australia, Su *et al.*[18] estimated annual costs of €364, €1297 and €977 for mild, moderate and severe eczema, respectively. In Italy, Ricci *et al.*[23] estimated annual costs of €727, €1228 and €1896 for mild, moderate and severe eczema, respectively; most of the family costs were for emollients and detergents in all three severity categories.

Discussion

Our results clearly show that substituting NPs for dermatologists in the treatment of eczema in children provides savings in both healthcare costs and family costs. Care provided by the NPs was at least as effective as that provided by the dermatologists and may be preferable from a health economic perspective.

Healthcare costs for outpatient visits were lower in NP-led care because of the lower salary costs, and because of a lower number of outpatient visits in children aged < 4 years. This was somewhat offset by higher telephone costs in the NP group because carrying out extensive counselling by phone was accompanied by additional costs. The treatment period in the hospital was longer in the dermatologist group. Nevertheless, after treatment in the hospital was completed, the costs for visits to the general practitioner were higher in the dermatologist group indicating that patients treated by the NP were autonomous more quickly and independent of the secondary care, and, moreover, lower costs were subsequently incurred in primary care.

The effect of education and counselling by the NP was not reflected in the quality of life and severity outcomes. Possibly, dermatologists achieved similar results in terms of the quality of life because they prescribed 'stronger' medication, as mean annual costs for medication were higher in the dermatologist group.

Family costs in the NP group were half that in the dermatologist group, which was mainly explained by time costs and out-of-pocket expenses. Lower time costs were determined by the lower number of treatment visits per patient in children aged < 4 years enabling parents to reduce the amount of lost time for travelling to the hospital. Costs for out-of-pocket expenses were higher in the dermatologist group indicating that without education and counselling patients continued searching for alternatives.

To our knowledge, this is the first clinical trial on cost-effectiveness of treatment by the NP compared with treatment by the dermatologist for eczema. We used IDQOL and CDLQI scores as a primary outcome measure in the ICER, which is unusual. However, decision-makers may view our results as substantial cost-savings in the NP-treated group even if the quality-of-life improvement after 12 months is on average comparable. The cost-effectiveness analysis on satisfaction clearly showed that treatment by the NP was cost-effective based on lower costs and gained patient satisfaction in 92% of the replicates, indicating that treatment by the NP may be the preferred choice. However, there are limitations to this preference. It should be considered that time investment by the NP was almost twice that by the dermatologist which may lead to lower productivity. The parents who participated in this trial were predisposed to accept NPs, as a result of which they may be more satisfied with NPs. It is also unclear whether satisfaction is biased by the individual NP's characteristics, because in the current study treatment was mainly carried out by one NP. Satisfaction is essential to understanding

Table 7 Review cost assessment

Author	Currency	Cost components	Cost units	Mean annual costs per child (EURO, 2008)		
Su *et al.* 1997[18]	Aus dollar			Mild eczema (n = 18)	Moderate eczema (n = 20)	Severe eczema (n = 10)
		Healthcare costs	Visits (GP, dermatologist, paediatrician, allergist)	158	295	1297
			Hospital admission days	343	1154	486
			Total healthcare costs	501	1448	2206
		Family costs	Visits (GP, SC contribution)	13	22	2692
			Visits other (alternative practitioner)	70	57	23
			Medication (+ dressings)	168	379	203
			Other management strategies[a]	178	363	463
			Diet	0	61	111
			Time costs	114	677	273
			Total family costs	364	1297	977
Rathjen *et al.* 2000[21]	Deutsche mark			Moderate and severe eczema (n = 204)		
		Healthcare costs	Visits (GP, dermatologist, paediatrician, internal medicine, psychologist, dietician, alternative therapist)	494		
			Medication	421		
			Hospital admission days	384		
			Rehabilitation clinic	526		
			Total healthcare costs	1498		
		Family costs	Contribution healthcare costs	326		
			Other management strategies[b]	1095		
			Diet	326		
			Time costs (including loss of earnings)	2321		
			Total family costs	4068		
Emerson *et al.* 2001[22]	U.K. pound			Eczema all severity (n = 290)[c]		
		Healthcare costs	Visits (GP, health visitor/practice nurse, dermatologist, paediatrician)	51		
			Emergency room	0·2		
			Medication	39		
			Total healthcare costs all severity	90		
		Family costs	Visits (private specialist)	3		
			Visits other (alternative therapist)	10		
			Other management strategies[a]	14		
			Emollients, bath preparation, diet	10		
			Transport	8		
			Time costs	7		
			Total family costs	52		
Weinmann *et al.* 2003[20]	US dollar			Eczema all severity (n = 90)		
		Healthcare costs	Visits (GP, eczema specific physician visits in SC)	79		
			Medication	38		
			Hospital admission days	30		
			Rehabilitation clinic	70		
			Diagnostics	2		
			Emergency room	7		
			Total healthcare costs all severity	228		
				Mild eczema (n = 53)	Moderate eczema (n = 26)	Severe eczema (n = 11)
			Total healthcare costs	170	433	947

Table 7 Continued

Author	Currency	Cost components	Cost units	Mean annual costs per child (EURO, 2008)		
Ricci *et al.* 2006[23]	US dollar			Eczema all severity (n = 33)		
		Family costs	Visits (SC + private specialist)	161		
			Medication	73		
			Emollients, detergents	808		
			Other management strategies[a]	49		
			Total family costs all severity	1313		
				Mild eczema (n = 5)	Moderate eczema (n = 20)	Severe eczema (n = 8)
			Visits (SC + private specialist)	34	172	222
			Medication	84	59	84
			Emollients, detergents	528	808	1013
			Other management strategies[a]	0	49	75
			Diet	0	117	485
			Total family costs	727	1228	1896
Witt *et al.* 2009[19]	EURO			Mean eczema severity mild (n = 52)		
		Healthcare costs	Visits (dermatologist, paediatrician, other physician)	157		
			Hospital admission days	0		
			Medication	174		
			Total healthcare costs	331		
		Family costs	Medical aids and adjuvant therapies	211		
			Time costs	149		
			Total family costs	360		

GP, general practitioner; SC, secondary care; HDM, house dust mite. [a]HDM avoidance intervention, nonirritating clothes. [b]HDM avoidance intervention, disease-related holidays, home changing, other. [c]Mild (n = 242), moderate (n = 41), severe (n = 7).

patients' preferences and providing feedback to professionals and managers, but it may have limitations as a measure for policy decisions. However, we showed that other indicators of utility such as the quality-of-life outcomes and eczema severity showed similar outcomes in both treatment groups. We collected data on costs as accurately as possible and we showed that treatment by the NP clearly generated lower costs. Therefore, we suggest that similar quality-of-life and severity outcomes, higher satisfaction with care and cost-savings are sufficient criteria to prefer NPs in the treatment of children with eczema.

Our overview of the costs showed that the costs associated with eczema in children vary considerably between studies. This can be explained partially by the differences in the study populations regarding the severity of eczema. Studies based on hospital-based recruitment generally include more severe cases. Witt *et al.*[19] reported annual healthcare costs of €331 in children with mild eczema in secondary care. We noted higher costs of €801 in children with moderate eczema in secondary care. Our results confirmed the findings by Su *et al.*[18] and Ricci *et al.*[23] that there is a positive association between the costs and the severity of eczema. Another explanation for the variation in healthcare costs between studies is that the types of costs included were different. Some studies calculated only eczema-specific costs while other studies also calculated eczema-related costs, for example visits to a dietician or allergologist. Rathjen *et al.*[21] reported mean healthcare costs of €1498; these consisted largely of sanatorium visits, which exist only in the German healthcare system. Comparisons of family costs were difficult because different types of family costs were determined and the calculation of costs was different in the various countries. The contribution of the family for medication and emollients differed particularly between countries. In the Netherlands, prescriptions for emollients and protective dressings are paid by health insurance, but bath oil has to be paid for by the family. This explains the lower family costs in the Netherlands than in Italy where costs of emollients are paid by the family.

In conclusion, international comparisons of the costs of eczema in children are difficult because of the variation in the types of costs determined, units and unit prices and eczema severity between studies. To date, only a few international studies have assessed the economic burden of eczema in children and further studies are needed to calculate the disease costs and also to investigate whether nurse-led care leads to lower costs. Our economic evaluation showed that the costs of

care provided by the NPs were lower than care provided by the dermatologists with comparable effectiveness. Therefore, NP-led care is considered to be cost-effective. Because eczema is a chronic disease, treatment by NPs may result in long-term cost reductions both from a healthcare perspective and a family point of view while maintaining effectiveness.

What's already known about this topic?

- Care of eczema in children provided by nurse practitioners (NPs) has similar outcomes in severity and the quality of life, and higher satisfaction than that provided by a dermatologist.

What does this study add?

- Substituting NPs for dermatologists in the treatment of children with eczema results in lower healthcare costs and family costs.
- The economic burden of treatment of eczema in children is summarized in our review.

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